CLAIMS

We claim:

1. A process for manufacturing a semiconductor integrated circuit device, which comprises the steps of:

(a) forming, over the silicon surface on a main surface of a wafer, an insulating film having an effective film thickness less than 5 nm in terms of SiO_2 and made of a single insulating film containing silicon oxide as a principal component or a composite film thereof with another insulating film;

(b) forming, over the insulating film, a metal film containing a refractory metal as a principal component without disposing, therebetween, an intermediate layer containing polycrystalline silicon as a principal component;

(c) heat treating the wafer in a water-vapor- and and hydrogen-containing gas atmosphere having a water vapor/hydrogen partial pressure ratio set at a ratio permitting oxidation of silicon without substantial oxidation of the refractory metal; and

(d) after step (c), patterning the metal film to form a metal gate electrode.

2. The process according to claim 1, wherein the refractory metal is molybdenum or tungsten.

3. A processing according to claim 1, wherein the insulating film has an effective film thickness less than 4 nm in terms of SiO_2.

4. A process according to claim 1, wherein the insulating film has an effective film thickness less than 3 nm in terms of SiO_2.

5. A process for manufacturing a semiconductor integrated circuit device, which comprises the steps of:

(a) forming, over the silicon surface on a main surface of a wafer, an insulating film having an effective film thickness less than 5 nm in terms of SiO_2 and made of a single insulating film containing silicon nitride as a principal component or a composite film thereof with another insulating film;

(b) forming, over the insulating film, a metal film containing a refractory metal as a principal component without disposing, therebetween, an intermediate layer containing polycrystalline silicon as a principal component;

(c) heat treating the wafer in a water-vapor- and hydrogen-containing gas atmosphere having a water vapor/hydrogen partial pressure ratio set at a ratio permitting oxidation of silicon without substantial oxidation of the refractory metal; and

(d) after step (c), patterning the metal film to form a metal gate electrode.

6. A process according to claim 5, wherein the refractory metal is molybdenum or tungsten.

7. A process according to claim 5, wherein the water-vapor- and hydrogen-containing gas further contains a nitrogen or ammonia gas.

8. A process for manufacturing a semiconductor integrated circuit device, which comprises the steps of:

(a) forming, over the silicon surface on a main surface of a wafer, an insulating film having an effective film thickness less than 5 nm in terms of SiO_2 and made of a single insulating film containing as a principal component a metal oxide having a dielectric constant larger than silicon dioxide or a composite film thereof with another insulating film;

(b) forming, over the insulating film, a metal film containing a refractory metal as a principal component without disposing, therebetween, an intermediate layer containing polycrystalline silicon as a principal component;

(c) heat treating the wafer in a water-vapor- and hydrogen-containing gas atmosphere having a water vapor/hydrogen partial pressure ratio set at a ratio permitting oxidation of the material of the insulating film without substantial oxidation of the refractory metal; and

(d) after step (c), patterning the metal film to form a metal gate electrode.

9. A process according to claim 8, wherein the metal constituting the metal oxide film is titanium, zirconium or hafnium.

10. A process according to claim 8, wherein the metal constituting the metal oxide film is tantalum.

11. A process according to claim 8, wherein the metal constituting the metal oxide film is aluminum.

12. A process according to claim 8, wherein the metal oxide film is a high dielectric substance including a ABO_3 type average perovskite structure and is in a paraelectric phase at an operating temperature.

13. A process according to claim 12, wherein the high dielectric substance is barium strontium titanate.